

We claim:

1. A particulate composition comprising at least two different nanocrystalline materials selected from the group consisting of the oxides and hydroxides of the elements of Groups IIA, IIIA, IVA, the transition metals and the lanthanide series of the Periodic Table, said
5 different materials being solidified and intimately intermingled on a molecular level, with at least one of the materials exhibiting an average crystallite size of from about zero up to about 4 nm by XRD analysis.

2. The composition of claim 1, including from 2-4 of said different materials.

3. The composition of claim 2, including 2 of said different materials.

4. The composition of claim 1, all of said different materials exhibiting an average crystallite size of from about zero to about 4 nm by XRD analysis.

5. The composition of claim 1, including aluminum oxide and magnesium oxide as said different materials.

6. The composition of claim 1, said composition having a BET surface area which is at least about 30% larger than the surface area of at least one of the nanocrystalline materials making up the composition, if said at least one nanocrystalline solid were prepared alone.

7. The composition of claim 6, said composition having a BET surface area which is at least about 50% larger than the surface area of at least one of the nanocrystalline materials making up the composition, if said at least one nanocrystalline solid were prepared alone.

8. The composition of claim 1, said different materials selected from the group consisting of the oxides and hydroxides of Al, Mg, Ca, Sr, Ba, Zn, Co, Ni, Fe, Ti, Pd, Rh, V, Mn, Ga and Si.

9. The composition of claim 1, there being two of said different materials selected from the group consisting of the combinations, $\text{Al}_2\text{O}_3 \cdot \text{MgO}$, $\text{Al}_2\text{O}_3 \cdot \text{CaO}$, $\text{Al}_2\text{O}_3 \cdot \text{SrO}$, $\text{Al}_2\text{O}_3 \cdot \text{BaO}$, $\text{Al}_2\text{O}_3 \cdot \text{ZnO}$, $\text{Al}_2\text{O}_3 \cdot \text{CoO}$, $\text{Al}_2\text{O}_3 \cdot \text{NiO}$, $\text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$, $\text{Al}_2\text{O}_3 \cdot \text{MgO} \cdot \text{TiO}_2$, $\text{Al}_2\text{O}_3 \cdot \text{PdO}$, $\text{Al}_2\text{O}_3 \cdot \text{RhO}$, $\text{Al}_2\text{O}_3 \cdot \text{V}_2\text{O}_3$, $\text{Al}_2\text{O}_3 \cdot \text{MnO}$, $\text{Ga}_2\text{O}_3 \cdot \text{MgO}$, and $\text{SiO}_2 \cdot \text{MgO}$.

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10. The composition of claim 1, one of said materials being present in a greater amount by weight as compared with another of said materials.

11. The composition of claim 1, said composition being made up of first and second different nanocrystalline materials, with a molar ratio of the first and second materials ranging from about 0.1-10.

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12. A particulate composition comprising at least two different nanocrystalline materials selected from the group consisting of the oxides and hydroxides of the elements of Groups IIA, IIIA, IVA, the transition metals and the lanthanide series of the Periodic Table, said different materials being solidified and intimately intermingled on a molecular level, said composition having a BET surface area which is at least about 30% larger than the surface area of at least one of the nanocrystalline materials making up the composition, if said at least one nanocrystalline materials were prepared alone.

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13. The composition of claim 12, including from 2-4 of said different materials.

14. The composition of claim 13, including 2 of said different materials.

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15. The composition of claim 12, all of said different materials exhibiting a crystallite size of about zero to about 4 nm by XRD analysis.

16. The composition of claim 12, including aluminum oxide and magnesium oxide as said different materials.

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17. The composition of claim 12, said composition having a BET surface area which is at least about 50% larger than the surface area of at least one of the nanocrystalline materials making up the composition, if said at least one nanocrystalline solid were prepared alone.

5 18. The composition of claim 12, said different materials selected from the group consisting of the oxides and hydroxides of Al, Mg, Ca, Sr, Ba, Zn, Co, Ni, Fe, Ti, Pd, Rh, V, Mn, Ga and Si.

10 19. The composition of claim 12, there being two of said different materials selected from the group consisting of the combinations, $\text{Al}_2\text{O}_3 \cdot \text{MgO}$, $\text{Al}_2\text{O}_3 \cdot \text{CaO}$, $\text{Al}_2\text{O}_3 \cdot \text{SrO}$, $\text{Al}_2\text{O}_3 \cdot \text{BaO}$, $\text{Al}_2\text{O}_3 \cdot \text{ZnO}$, $\text{Al}_2\text{O}_3 \cdot \text{CoO}$, $\text{Al}_2\text{O}_3 \cdot \text{NiO}$, $\text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$, $\text{Al}_2\text{O}_3 \cdot \text{MgO} \cdot \text{TiO}_2$, $\text{Al}_2\text{O}_3 \cdot \text{PdO}$, $\text{Al}_2\text{O}_3 \cdot \text{RhO}$, $\text{Al}_2\text{O}_3 \cdot \text{V}_2\text{O}_3$, $\text{Al}_2\text{O}_3 \cdot \text{MnO}$, $\text{Ga}_2\text{O}_3 \cdot \text{MgO}$, and $\text{SiO}_2 \cdot \text{MgO}$.

5 20. The composition of claim 12, one of said materials being present in a greater amount by weight as compared with another of said materials.

20 21. The composition of claim 12, said composition being made up of first and second different nanocrystalline materials, with a molar ratio of the first and second materials ranging from about 0.1-10.

22. A gel comprising a mixture of at least two different hydroxides of the elements of Groups IIA, IIIA, IVA, the transition metals and the lanthanide series of the Periodic Table.

25 23. The gel of claim 22, including from about 2-4 of said different hydroxides.

24. The gel of claim 23, including two of said different hydroxides.

30 25. The gel of claim 22, including aluminum hydroxide and magnesium hydroxide as said different hydroxides.

26. The gel of claim 22, said different hydroxides selected from the group consisting of the hydroxides of Al, Mg, Ca, Sr, Ba, Zn, Co, Ni, Fe, Ti, Pd, Rh, V, Mn, Ga and Si.

27. The gel of claim 22, one of said hydroxides being present in a greater amount by weight as compared with another of said hydroxides.

28. The gel of claim 22, said composition being made up of first and second different hydroxides, with a molar ratio of the first and second hydroxides ranging from about 0.10-10.

29. The gel of claim 22, said gel including a quantity of water.

30. A solid composition comprising a mixture of at least two different solid hydroxides of the elements of Groups IIA, IIIA, IVA, the transition metals and the lanthanide series of the Periodic Table.

31. The composition of claim 30, including from about 2-4 of said different solid hydroxides.

32. The composition of claim 31, including two of said different solid hydroxides.

33. The composition of claim 30, including solid aluminum hydroxide and solid magnesium hydroxide as said different solid hydroxides.

34. The composition of claim 30, said different solid hydroxides selected from the group consisting of the solid hydroxides of Al, Mg, Ca, Sr, Ba, Zn, Co, Ni, Fe, Ti, Pd, Rh, V, Mn, Ga and Si.

35. The composition of claim 30, one of said solid hydroxides being present in a greater amount by weight as compared with another of said solid hydroxides.

36. The composition of claim 30, said composition being made up of first and second different solid hydroxides, with a molar ratio of the first and second solid hydroxides ranging from about 0.10-10.

5 37. A solid, particulate, nanocrystalline composition prepared by the thermal conversion of the hydroxide composition of claim 30 to the corresponding oxides.

38. A method of preparing a particulate nanocrystalline composition comprising the steps of:

10 separately preparing a plurality of different alkoxide solutions in a compatible solvent, each alkoxide including an ion moiety selected from the group consisting of the ions of the elements of Groups IIA, IIIA, IVA, the transition metals and the lanthanide series of the Periodic Table;

5 mixing and hydrolyzing said plurality of alkoxide solutions to give a gel comprising the corresponding hydroxides of said different alkoxides; and

drying said gel to yield a solid hydroxide composition or thermally converting said hydroxides to the corresponding solid oxides.

20 39. The method of claim 38, there being from 2-4 of said different alkoxide solutions.

40. The method of claim 38, there being 2 of said different alkoxide solutions.

25 41. The method of claim 40, including aluminum alkoxide solution and magnesium alkoxide solution as said different alkoxide solutions.

42. The method of claim 38, each of said different alkoxide solutions selected from the group consisting of the alkoxides including an ion moiety of Al, Mg, Ca, Sr, Ba, Zn, Co, Ni, Fe, Ti, Pd, Rh, V, Mn, Ga and Si.

43. The method of claim 38, each of said different alkoxides has the formula $[R-O]_n-X_q$, where R is a C1-C6 straight or branched chain alkyl group, X is said ion moiety, and n and q are selected so as to balance the valence of the alkoxide.

5 44. The method of claim 43, where R is a tert-butyl group.

45. Solid oxides produced by the method of claim 38.

10 46. A method comprising the steps of contacting a target material with a composition according to claim 1, and causing adsorption reaction to occur between the target material and said composition.

15 47. The method of claim 46, said target material selected from the group consisting of compounds selected from the group of acids, alcohols, aldehydes, compounds containing an atom of P, S, N, Se, or Te, hydrocarbon compounds, toxic metal compounds, halogenated compounds, bacteria, fungi, viruses, rickettsiae, chlamydia, and toxins.

20 48. The method of claim 46, said contacting step comprising the step of contacting a fluid containing said target material with a quantity of said composition.

49. The method of claim 46, said contacting step comprising the step of distributing a quantity of said composition onto an area where said target material is present.

25 50. The method of claim 46, said contacting step being carried out at a temperature of from about -70-800°C.

51. The method of claim 50, said temperature being from about -25-100°C.

30 52. A method of adsorbing a target compound comprising the step of contacting the target compound with composition according to claim 12.

53. The method of claim 52, said target material selected from the group consisting of compounds selected from the group of acids, alcohols, aldehydes, compounds containing an atom of P, S, N, Se, or Te, hydrocarbon compounds, toxic metal compounds, halogenated compounds, bacteria, fungi, viruses, rickettsiae, chlamydia, and toxins.

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54. The method of claim 52, said contacting step comprising the step of contacting a fluid containing said target material with a quantity of said composition.

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55. The method of claim 52, said contacting step comprising the step of distributing a quantity of said composition onto an area where said target material is present.

56. The method of claim 52, said contacting step being carried out at a temperature of from about -70-800°C.

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57. The method of claim 56, said temperature being from about -25-100°C.

58. Nanocrystalline aluminum oxide having an average BET surface area of at least about 700 m²/g.

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59. The aluminum oxide of claim 58, said surface area being from about 725-850 m²/g.

60. The aluminum oxide of claim 58, said aluminum oxide exhibiting an amorphous pattern by XRD analysis.

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61. A method of adsorbing a target compound comprising the step of contacting the target compound with aluminum oxide according to claim 60.

62. The method of claim 61, said target material selected from the group consisting of compounds selected from the group of acids, alcohols, aldehydes, compounds containing an atom of P, S, N, Se, or Te, hydrocarbon compounds, toxic metal compounds, halogenated compounds, bacteria, fungi, viruses, rickettsiae, chlamydia, and toxins.

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63. The method of claim 61, said contacting step comprising the step of contacting a fluid containing said target material with a quantity of said aluminum oxide.

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64. The method of claim 61, said contacting step comprising the step of distributing a quantity of said aluminum oxide onto an area where said target material is present.

65. The method of claim 61, said contacting step being carried out at a temperature of from about -70-800°C.

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66. The method of claim 65, said temperature being from about -25-100°C.